

AERMOD Version 13350 Low Wind Options: Sensitivity Analysis and Evaluation Update

Study conducted on behalf of:

- API for sensitivity analysis
- Lignite Energy Council for evaluation update

Outline of Presentation

- Purpose and objectives of this study for AERMOD low wind options
- Sensitivity Study Funded by API
 - Model Options Tested
 - Source Types Modeled for Flat and Complex Terrain
 - Results of Sensitivity Analysis
- Evaluation Study Funded by Lignite Energy Council
 - Models and Options Tested
 - Database Tested to Date
 - Results of Evaluation Tests to Date

Purpose and Objectives: Sensitivity Analysis

- Explore the sensitivity of the AERMOD low wind speed options for predicted impacts in both flat and complex terrain
- Tested for a variety of emission sources of interest to the American Petroleum Institute and their members
- 11 different source types were examined, ranging from tall buoyant point sources to low-level fugitive sources
- Examined types of sources significantly affected by use of the low wind options in AERMET and AERMOD
- NO₂ was the pollutant selected → assumed full conversion of NO_x to NO₂
- Model setup was based on hypothetical locations, but used input parameters and building downwash (when applicable) from real model applications

Model Configurations and Options for Sensitivity Analysis

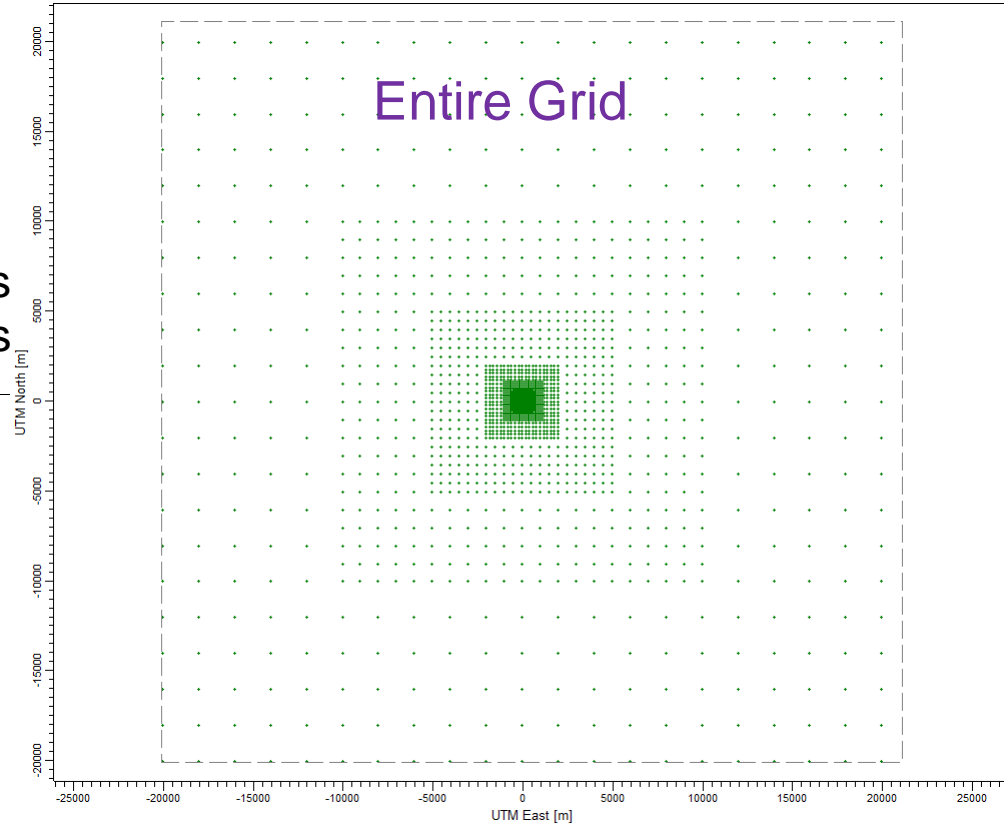
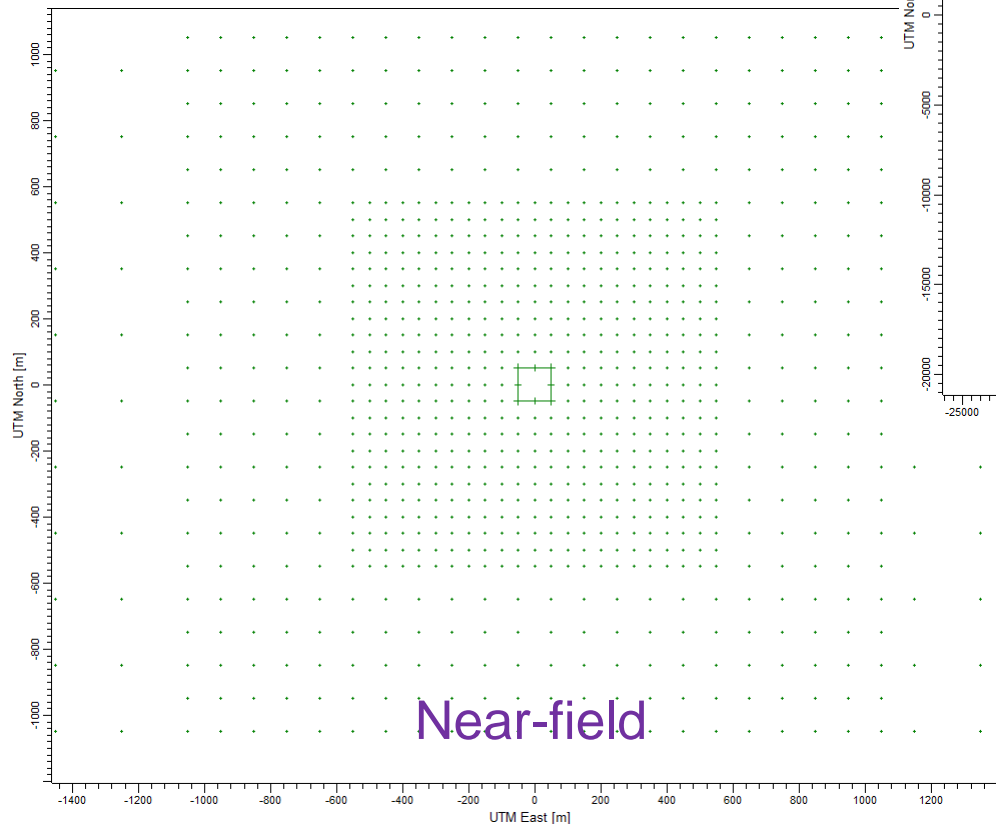
- AERMET/AERMOD Versions 13350 and 14134
- Three model configurations were run
 1. AERMET/AERMOD all default
 2. AERMET (Beta u^*) / AERMOD (default)
 3. AERMET (Beta u^*) / AERMOD (LOWWIND2)
- Each model configuration was run for each source in both flat and complex terrain
- Results from AERMOD versions 13350 and 14134 were the same

Model Inputs: Source Types

Source ID	Source Description	Stack Height (m)	Stack Temp (K)	Stack Vel. (m/s)	Stack Diameter (m)
FCC	Source 1: a tall buoyant point source indicative of an FCC (fluid catalytic cracking) refinery source (including building downwash)	54.0	561.0	49.1	2.0
FLARE	Source 2: a tall buoyant point source representing a flare <i>(pseudo temp and velocity modeled to conserve buoyancy flux)</i>	75.6	1273.0	20.0	1.1
REGENHTR	Source 3: a tall buoyant point source indicative of a CCR (continuous catalytic regenerative reformer) refinery source (including building downwash)	104.2	450.0	12.2	3.7
GASTURB	Source 4: a buoyant point source indicative of gas turbine at a compressor station (including building downwash)	13.7	777.0	41.6	1.2
DIESENG	Source 5: a short-stack horizontal release point source indicative of a diesel generator (including building downwash)	9.1	697.0	0.001	0.60
DRILLRIG	Source 6: a buoyant point source indicative of a drill rig (e.g., used at a fracking site, including building downwash)	6.1	665.0	45.0	0.3
LNGTURB	Source 7: a combustion turbine source indicative of drilling or LNG facility operations.	13.7	777.0	30.0	3.0
PNTTANK	Source 8: a non-buoyant point source located on a tank (including downwash)	14.6	ambient	0.001	0.001
COMPRSTA	Source 11: buoyant point source associated with a compressor station at a coal bed methane drilling site (including downwash)	14.3	449.8	22.8	1.8
		Release Height (m)	X-Dim. (m)	Y-Dim. (m)	Initial Sigma-Z (m)
AREA	Source 9: a ground-level area source	0.0	50.0	50.0	0.0
		Release Height (m)	Initial Sigma-Y (m)	Initial Sigma-Z (m)	
ROADVOL	Source 10: a volume source representing roadway traffic	10.0	14.0	16.0	

Model Inputs: Receptors

- 50 meter spacing out to 500 meters
- 100 meter spacing out to 1,000 meters
- 200 meter spacing out to 2,000 meters
- 500 meter spacing out to 5,000 meters
- 1,000 meter spacing out to 10,000 meters
- 2,000 meter spacing out to 20,000 meters

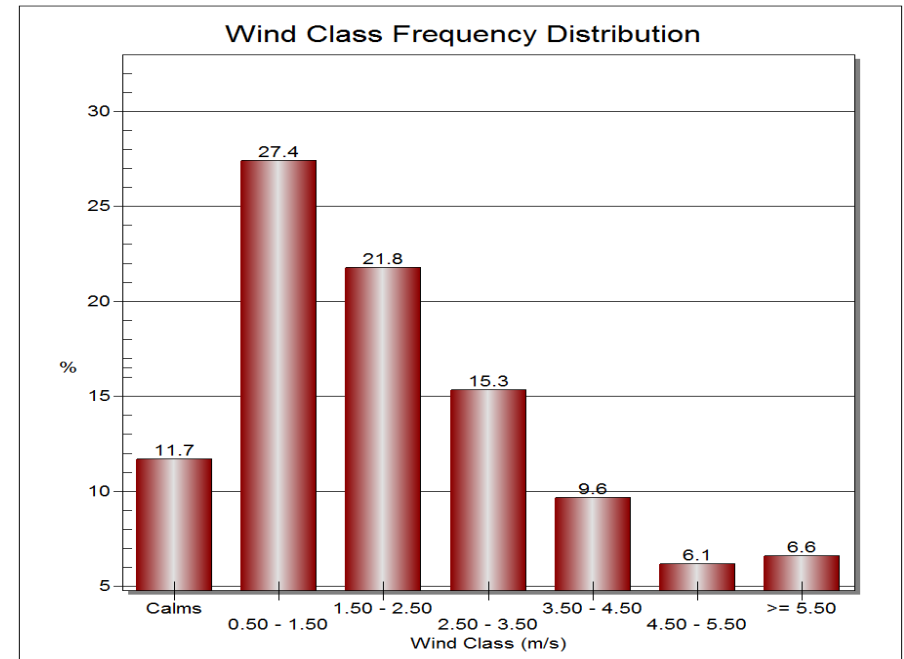
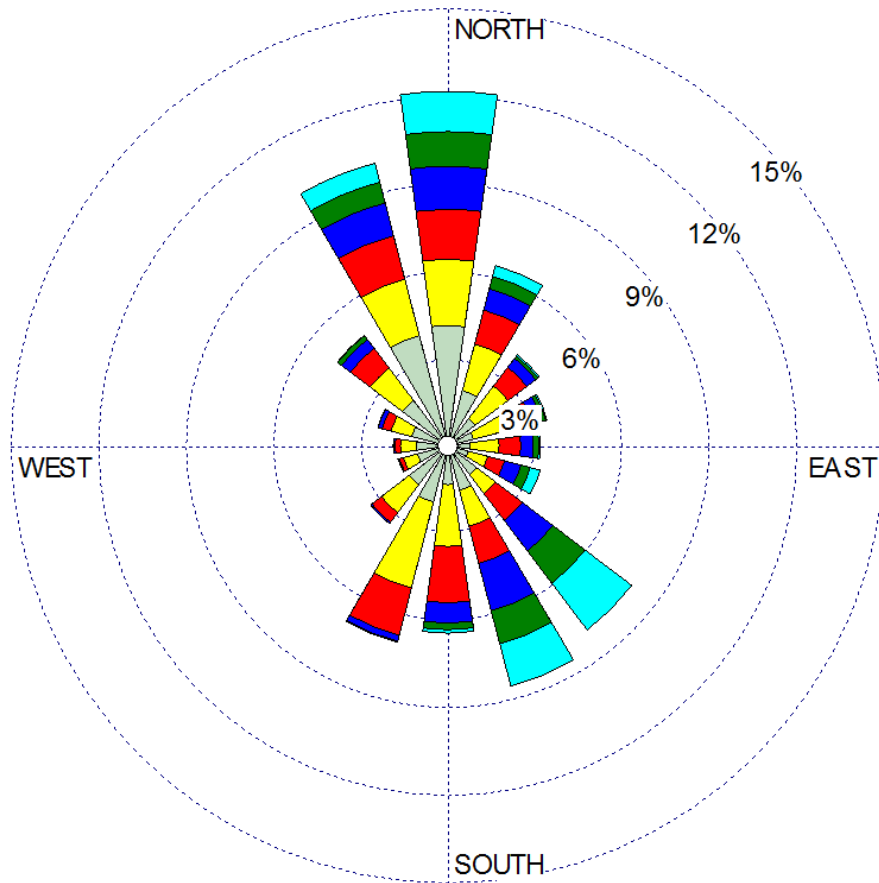


- Additional receptors placed in complex terrain areas
- AERMAP was used to calculate elevation and critical hill heights for all receptors

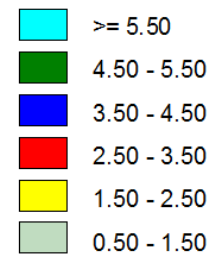
Model Inputs: Meteorology

- Two meteorological databases used in the study
 1. Flat Terrain - **2007-2011 from Pascagoula, Mississippi**
 2. Complex Terrain - **2008-2012 from Page, Arizona**
- *Both meteorological databases feature a fairly large percentage of low wind speed hours*
 - *Winds < 1.5 m/s at least 25% of the time*
 - *Winds < 2.5 m/s at least 60% of the time*
- *The location of the hypothetical sources in complex terrain was strategically positioned near (and upwind of) a major terrain feature*

Flat Terrain Wind Rose and Frequency Distribution

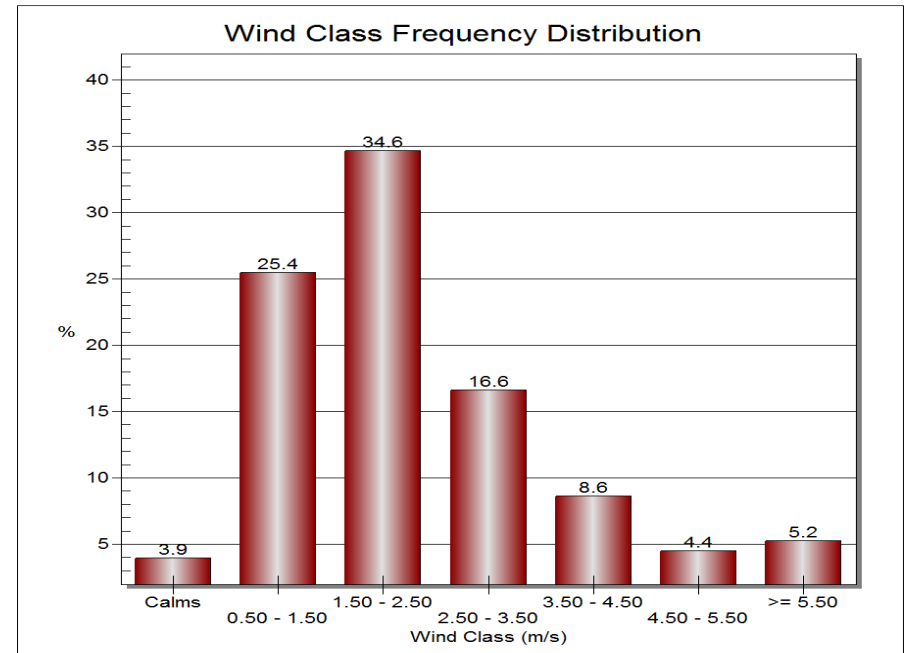
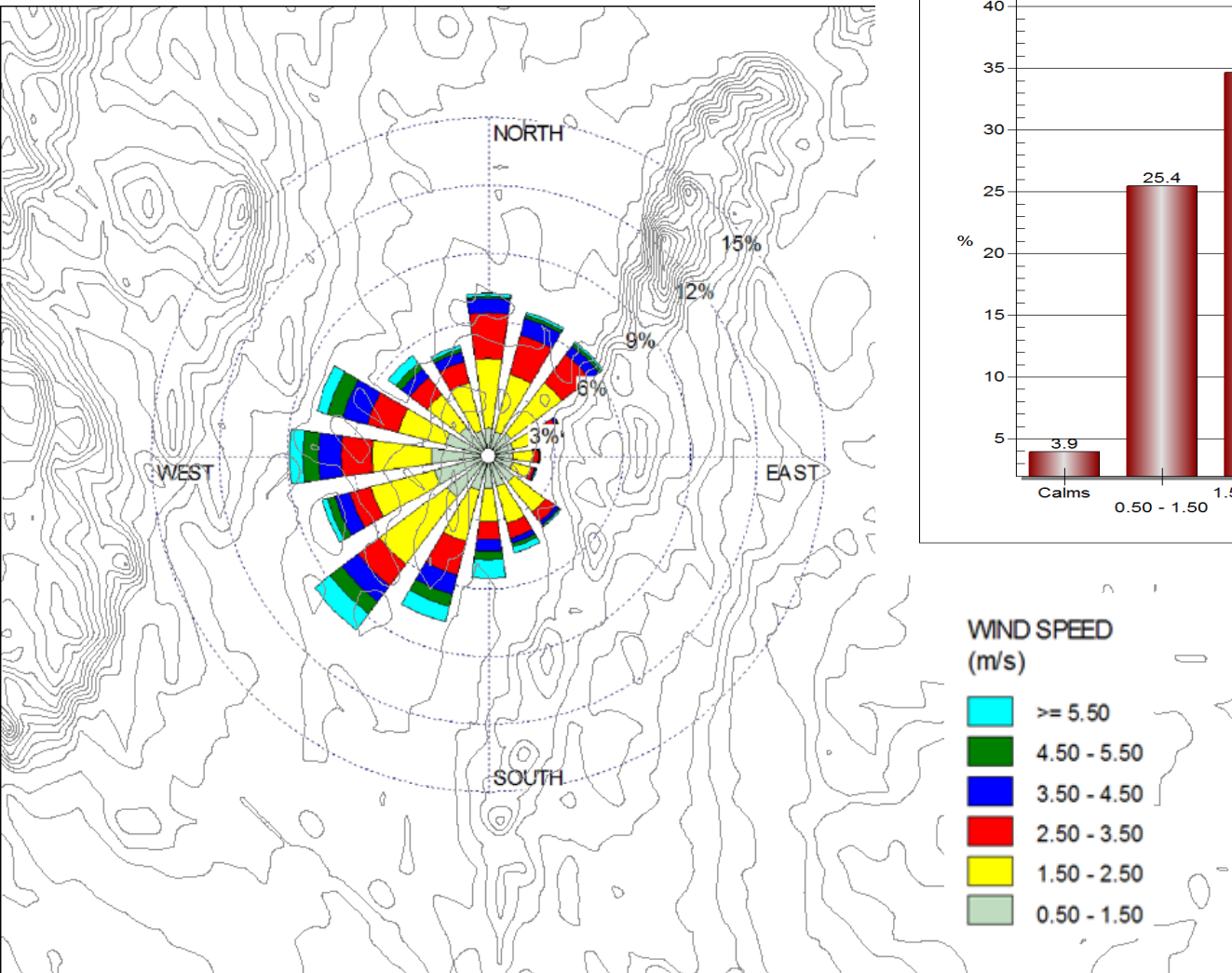


WIND SPEED
(m/s)



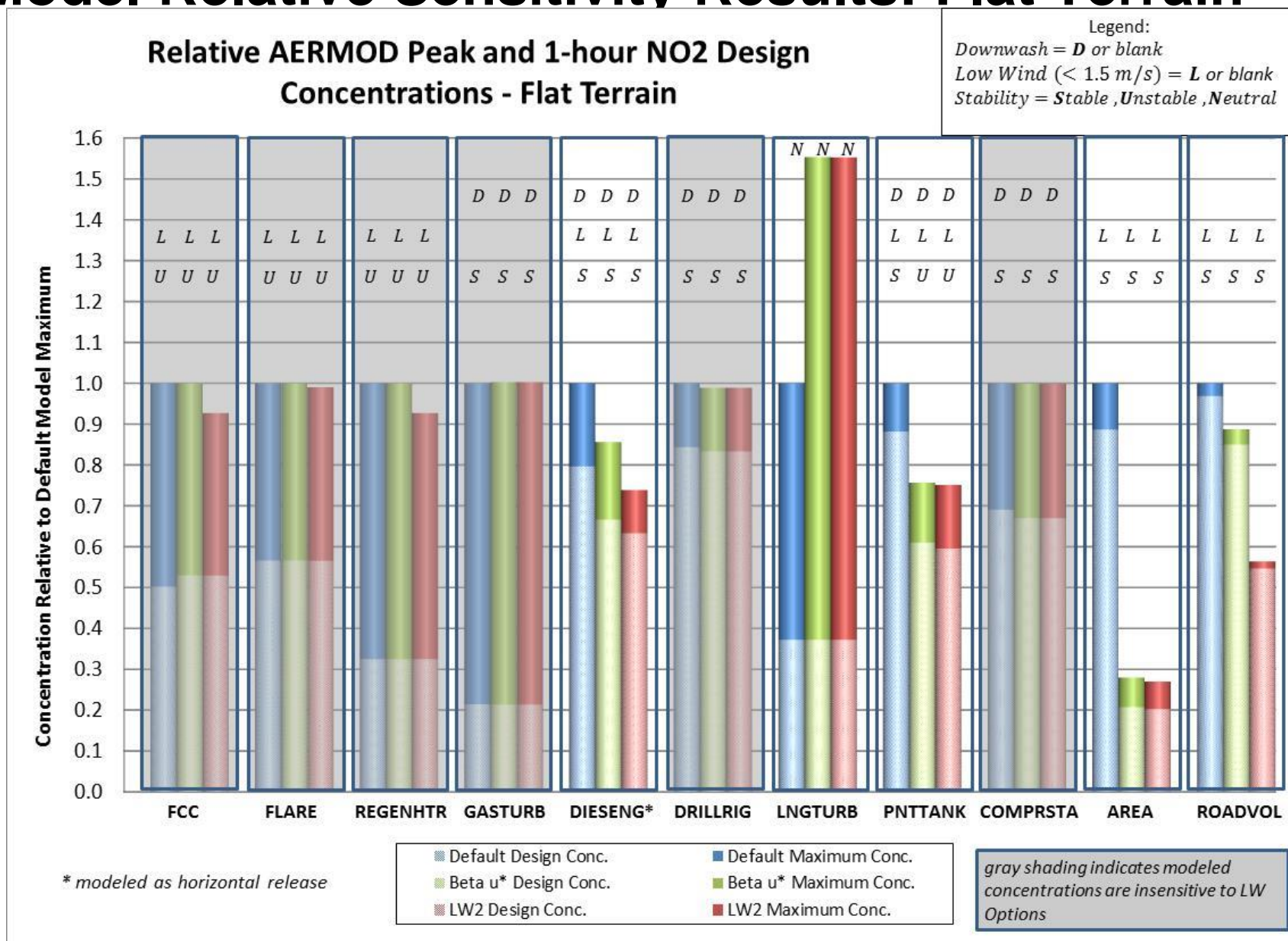
Wind speeds
< 2.5 m/s
over 60%
of the time

Complex Terrain Wind Rose



Wind speeds
< 2.5 m/s
over 60%
of the time

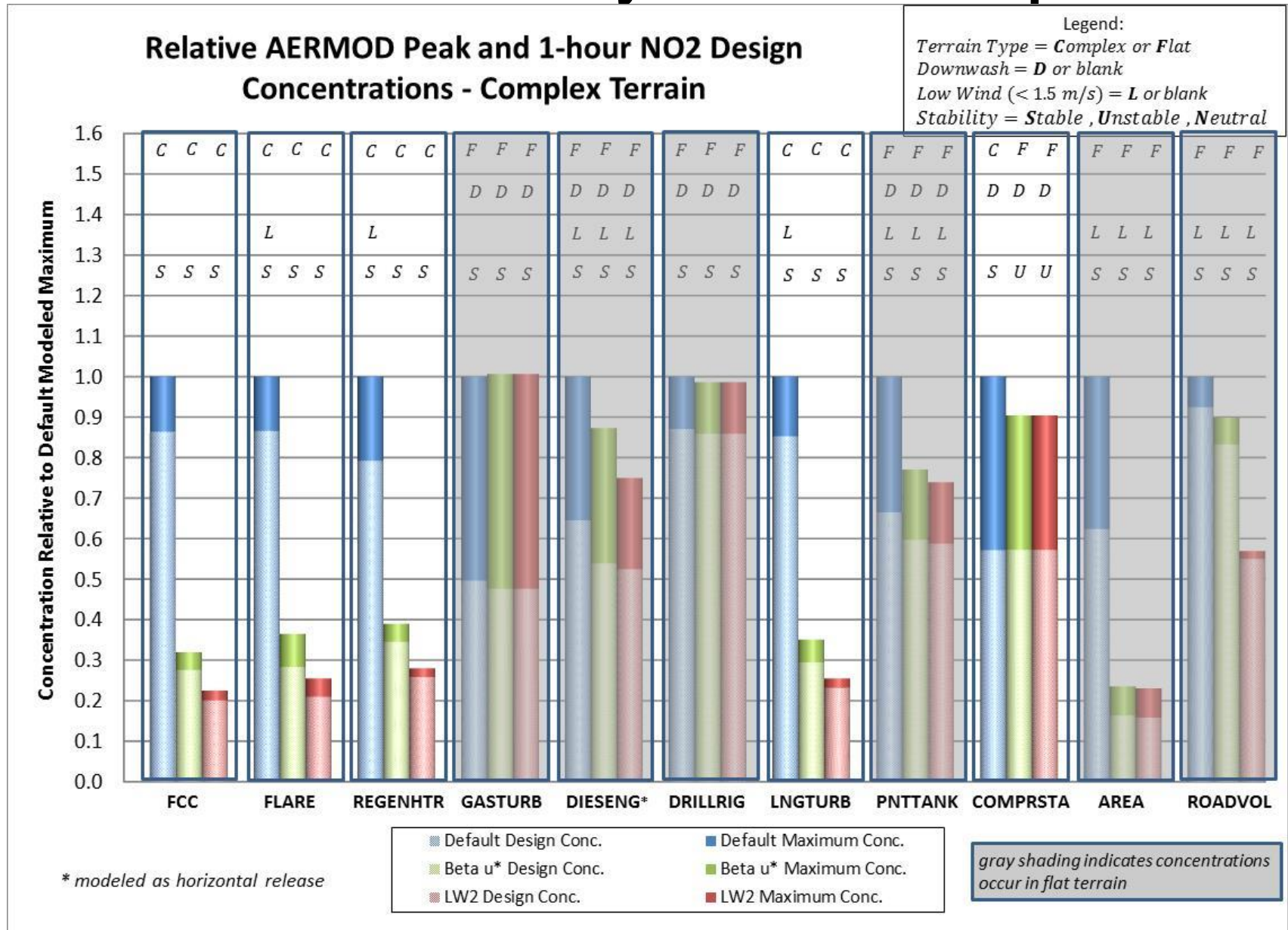
Model Relative Sensitivity Results: Flat Terrain



AERMOD Low Wind Sensitivity – Flat Terrain

- Tall buoyant stacks (FCC, FLARE, REGENHTR) were insensitive to the LW options - max impacts occur during unstable conditions
- Short buoyant stacks with downwash (DRILLRIG, COMPRSTA) insensitive to LW options - max impacts did not occur under light winds
- Short stacks without either momentum or buoyancy with downwash (**DIESENG**, **PNTTANK**) and fugitive sources are sensitive to LW options resulting in lower concentrations
 - max impacts occurred under light wind stable conditions
 - beta u^* increase mechanical mixing and vertical dispersion
- **LNGTURB** (short buoyant non-downwashing) source experienced a high wind “side effect” of the LW options
 - max impacts occur under high wind neutral conditions
 - use of beta u^* causes higher turbulence and plume touch down closer to the stack
- Low-level sources have peak impacts at low terrain near fenceline in complex terrain case as well

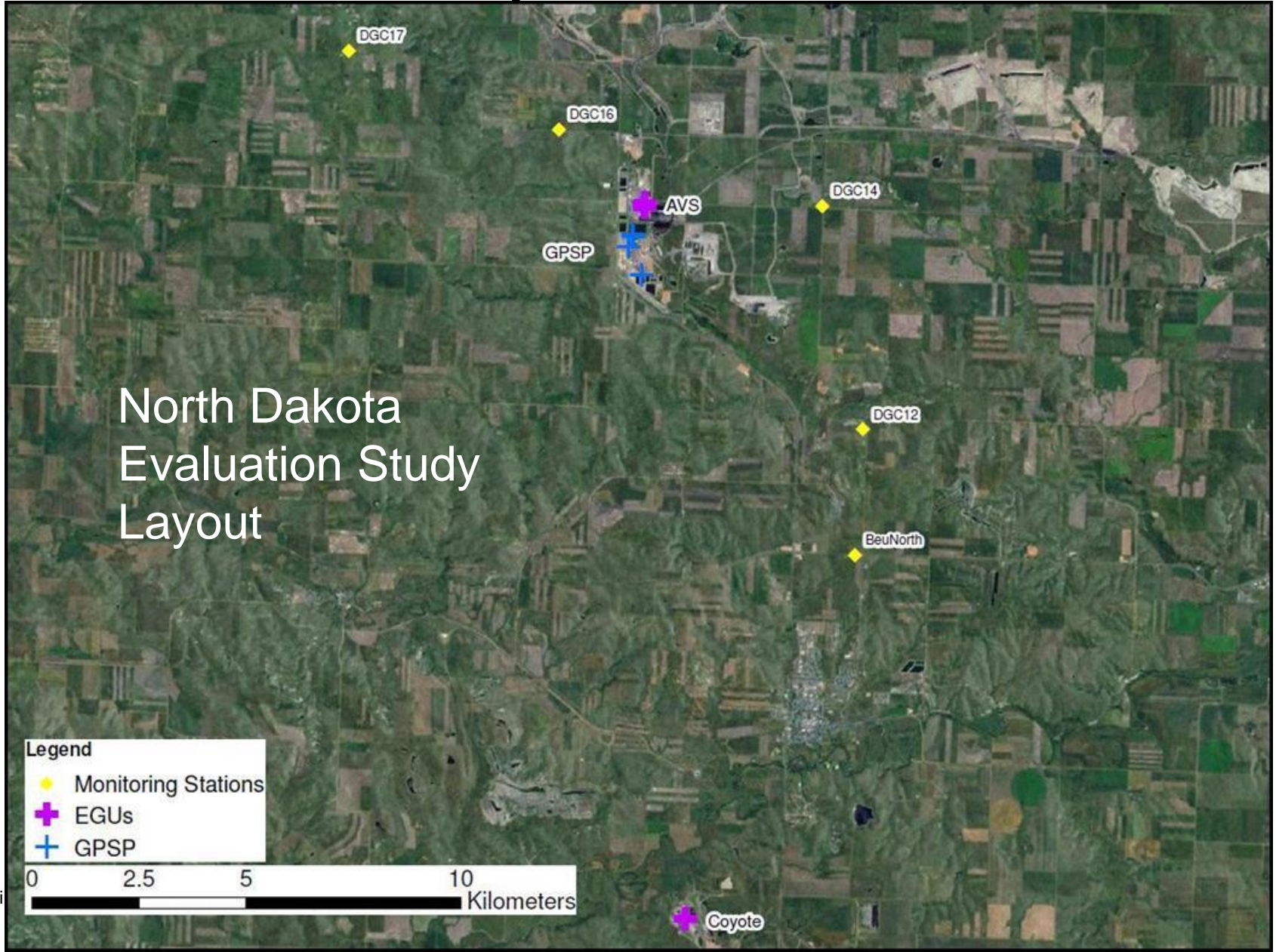
Model Relative Sensitivity Results: Complex Terrain

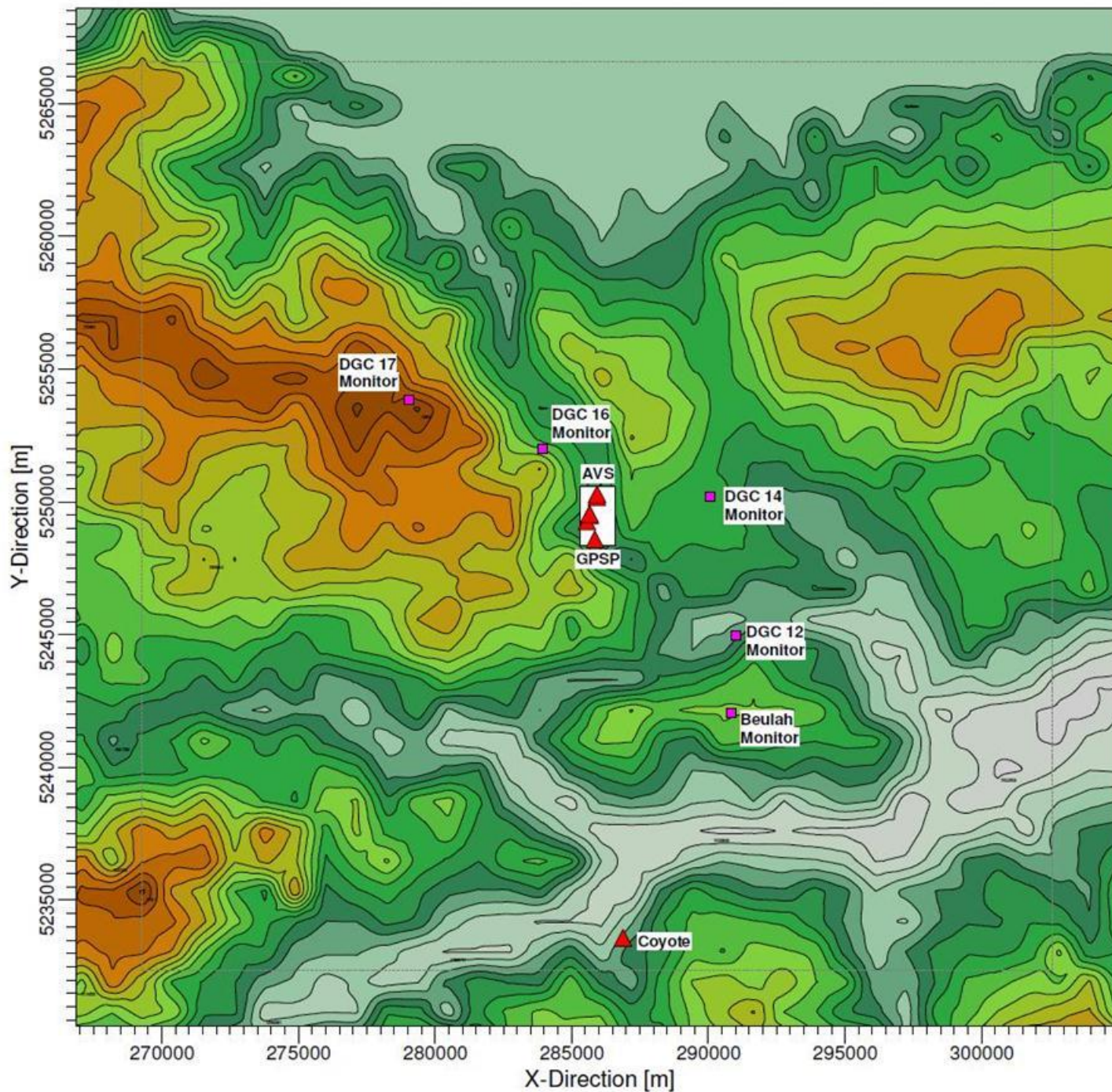


AERMOD Low Wind Sensitivity – Complex Terrain

- Tall buoyant stacks (**FCC, FLARE, REGENHTR**) are sensitive to the LW options in complex terrain
 - For default options, max impacts occur under light wind speed stable conditions
 - use of beta u^* increases effective wind speed, mechanical mixing, vertical dispersion, and plume rise; reduces predicted concentrations
 - use of LowWind2 also increases lateral dispersion and lower concentrations
- **LNGTURB** (short, non-downwashing) is sensitive to LW options
 - For default options, max impacts occur under light wind stable conditions
 - use of beta u^* increases mechanical mixing height and vertical dispersion
- **COMPRSTA** (short, downwashing) responds to LW options
 - For default options, max impact occurs under stable conditions (downwash)
 - Lower max impact for beta u^* option occurs in downwash during high wind unstable conditions

Lignite Energy Council Evaluation of AERMOD Low Wind Options for Tall Stack Releases





Terrain Contours for SO₂ Monitors Used in the ND Study

(10-m
contour
interval)

Preliminary AERMOD Evaluation Results* with Actual Hourly Emissions for North Dakota 4-year Database (07-10)

Monitor	Obs. Conc. 4-yr Avg 99th % Daily Max, $\mu\text{g}/\text{m}^3$	AERMOD 14134 with default options: Pre/obs ratio	AERMET with beta u^* , default AERMOD: Pre/obs ratio	AERMET with beta u^* , AERMOD with LOWWIND2 with min sigma-v = 0.5 m/s: Pre/obs ratio
DGC #12	91.52	1.28	1.28	1.05
DGC #14	95.00	1.45	1.45	1.05
DGC #16	79.58	2.00	2.00	1.58
DGC #17	83.76	2.07	1.49	1.29
Beulah	93.37	1.31	1.31	1.01

* Note: assumes SO_2 background of $10 \mu\text{g}/\text{m}^3$

Conclusions

- This study reports sensitivity and field evaluation results for low wind options in AERMET/AERMOD
- Sensitivity was tested for 11 different source types
- In flat terrain, this option is important for low-level, non-buoyant source types, and not for tall, buoyant stacks
- In complex terrain, this option is very important for tall, buoyant stack releases
- Low wind speed evaluations are underway for real-world field databases featuring tall, buoyant stacks: ND, Gibson
- For the North Dakota database, low wind options lead to better AERMOD performance, especially for the elevated terrain monitor. SCICHEM does well for this database.